Appendix CC

Stormwater

Peka Peka to North Otaki Expressway Project

Specialist Report - Stormwater

(For inclusion in the Social and Environmental Management Section of the SARA)

NZ Transport Agency
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Peka Peka to North Otaki Expressway Project
Specialist Report - Stormwater
(For inclusion in the Social and Environmental Management Section of the SARA)

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Contents

1 Executive Summary

The stormwater effects on this project are primarily associated with: increased road connectivity (level of service) during flood events, increased flooding levels; and short term and long-term changes to the pollutant load in the road runoff.

- **Road connectivity**: The Project has a positive effect on the connectivity of the road corridor during flood events. The expressway road level is generally at a higher level than the existing State Highway 1 (SH1), so the expressway will be free from flooding in a 1% AEP storm event.

- **Downstream flooding levels**: The increased impermeable area of the expressway would cause a very small increase in the downstream flood levels; however peak flow attenuation is being included in the Project to mitigate this effect.

- **Short term increase in sediment loads**: During construction there will be the potential for exposed soil to be washed into streams when it rains. This effect will be reduced by compliance with Regional Council erosion and sediment control guidelines.

- **Long term changes to the pollutant load**: The pollutants washed off the road when it rains originate from vehicles and people, not from the road pavement. For the same number of road users, the amount of pollutants generated would be expected to drop slightly as users on the expressway will be braking and cornering less than users on the existing SH1. In addition, there should be a significant reduction of pollutants reaching the receiving waterways as no road runoff from the existing SH1 is formally treated, whereas almost all road runoff from the expressway will go through formal treatment swales before being discharged to the receiving waterways.

During construction there will be an overall negative stormwater effect, but in the long-term the overall stormwater effect will be positive.

2 Introduction

Opus has been commissioned by the New Zealand Transport Agency (NZTA) to develop the scheme design for the Wellington North Corridor Road of National Significance (RoNS) from Peka Peka to Otaki North.

For further information of the design of the stormwater elements of the Project, refer to the '*Peka Peka to Otaki North Stormwater Design Philosophy Statement*' 2011 report.

2.1 Report Purpose

The purpose of this report is to document the stormwater related effects of the Project and to inform the 'Social and Environmental Management' Section of the main scheme assessment report addendum (SARA). Stormwater includes:

- erosion and sediment control during construction
- collection and conveyance of road runoff
- treatment and attenuation of road runoff
- stream erosion protection, from increased surface runoff
- small to medium waterway crossings.

Although closely related, this report does not cover large waterway crossings and regional flooding issues.

2.2 Project Location

The Project is located on the Kapiti Coast adjacent to the existing SH1, extending from the Peka Peka Beach junction to just north of Otaki.

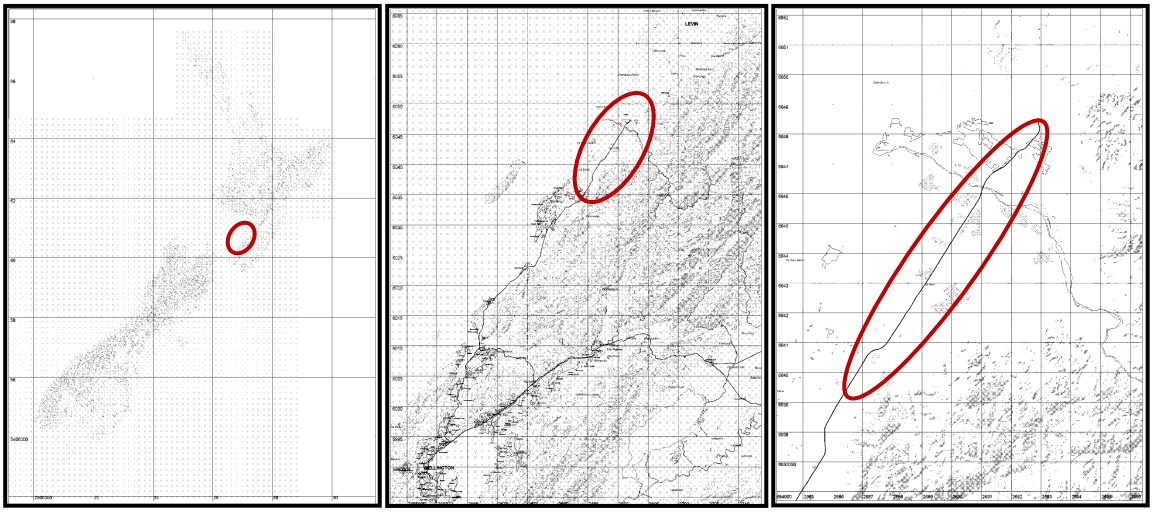

Figure 1 - Project Location Maps

3 Project Description

The planned upgrading of SH1 between Peka Peka and Otaki North is "*part of the Wellington Northern Corridor Road of National Significance (RoNS) – a planned four-lane expressway from Wellington Airport to Levin.*"

SH1 is the major route in and out of Wellington, linking the centres of Palmerston North, Wanganui and Levin with Wellington. By improving transport networks through the Kapiti Coast, this project will contribute to economic growth and productivity.

Currently the Peka Peka to North Otaki section of SH1 has a relatively poor and worsening safety record. It also experiences high levels of congestion during peak periods, weekends and holiday periods. This congestion is compounded by a high proportion of local traffic, and an increasing level of shopping-generated parking and pedestrian movements in the Otaki urban area. A bypass of Otaki, and the provision of a high-standard highway through the area will increase the efficiency of movements between Wellington and the North, will ease local congestion, improve safety, and will facilitate local, regional and national economic development.

The scope of this project is therefore to construct a high quality four-lane expressway bypassing the township of Otaki and the settlement of Te Horo. Together with the MacKay's to Peka Peka section to the south, it forms the Kapiti Expressway and when both sections are completed will provide a superior transport corridor providing much improved, reliable and safer journeys through the Kapiti Coast.

The Project seeks to safeguard future double tracking of the main trunk rail line and also involves the relocation of the track through Otaki in order to accommodate the proposed expressway.

4 Site Description/Existing Environment

From a stormwater perspective, important elements of the site description include:

- Land topography (to define catchments).
- The Geology (to understand the areas of potential soakage).
- Man-made features (as these alter drainage paths).
- Waterways (to locate waterway crossings and any diversion needed).
- Density of future development in the wider catchments (to understand cumulative effects).

4.1 Existing Site Description

4.1.1 Topography

Land either side of the route generally consists of flat land to the west, and steep country to the east, with waterways flowing from east to west, towards the sea. Smaller waterways have defined flow paths to the east but some lose definition as they flow across the flat land to the west (possibly due to infiltration or artificial diversions to farm drainage channels).

The existing ground along most of the route alignment has low grades. The middle third has limited locations where stormwater can be discharged. The northern end (north of Otaki Township) rises into rolling country.

4.1.2 Geology

The landform of the project area is defined by a number of strong natural features including: the coastal edge, the coastal plain, the eastern foothills, and the rivers and streams.

The Southern two fifths of the road may be subject to debris flows, due to the small and steep nature of the catchments to the east.

Between Peka Peka Road and Te Horo Beach Road, there are underlying dune sand and inter-dune deposits, which are likely to contain peat deposits. North of Te Horo Beach Road, the underlying geology includes terrace alluvium and recent alluvium.

Generally, alluvium and inter-dune deposits are not good for stormwater disposal by infiltration. There may possibly be potential for infiltration in pockets of dune sand; however this should not be relied on as infiltration rates in dune sand can be disappointing. Soakage is expected to be better in the gravel deposits associated with the larger rivers.

4.1.3 Existing Man-made Features

The existing SH1 and North Island Main Trunk (NIMT) rail embankments alter the natural drainage patterns of the area. In isolated places the culverts under the railway act as a restriction, reducing the downstream flooding risk (however increase the upstream flooding risk).

Just north of the Otaki River is the Otaki stop bank. This alters the local drainage pattern particularly from the north.

4.1.4 Waterways of Significance

The three larger waterways noted below are cited in Greater Wellington Regional Council's (GWRC) Regional Freshwater Plan as having special significance.

The Otaki River is listed as:

- Containing 'Nationally Threatened Indigenous Fish' (species recorded are: short jawed kokopu, giant kokopu, banded kokopu, and koaro).
- Containing 'Important Trout Habitat'.
- Having 'Important Amenity and Recreational Values'.

The Waitohu Stream is listed as:

- Containing 'Nationally Threatened Indigenous Fish' (species recorded are: brown mudfish).

The Mangaone Stream is listed as:

- Containing 'Nationally Threatened Indigenous Fish' (species recorded are: short jawed kokopu, koaro, and banded kokopu).

The wetland of note is at Marycrest which consists of bush remnant, and as such is considered to have high ecological value. There will also be an associated high ground water level in this area.

4.1.5 Density of future development

The density of future development in the catchments that the expressway lies within is (and is expected to remain) low in most areas except around the Otaki Township. This has been assessed in detail in the Peka Peka to Otaki North Stormwater Design Philosophy Statement report.

4.2 Stormwater Catchment Maps

There are four main catchments that the existing state highway and proposed alignment cut through. These are the Waitohu, Otaki, Mangaone and Awatea (project assigned name) catchments as shown in Figure 2.

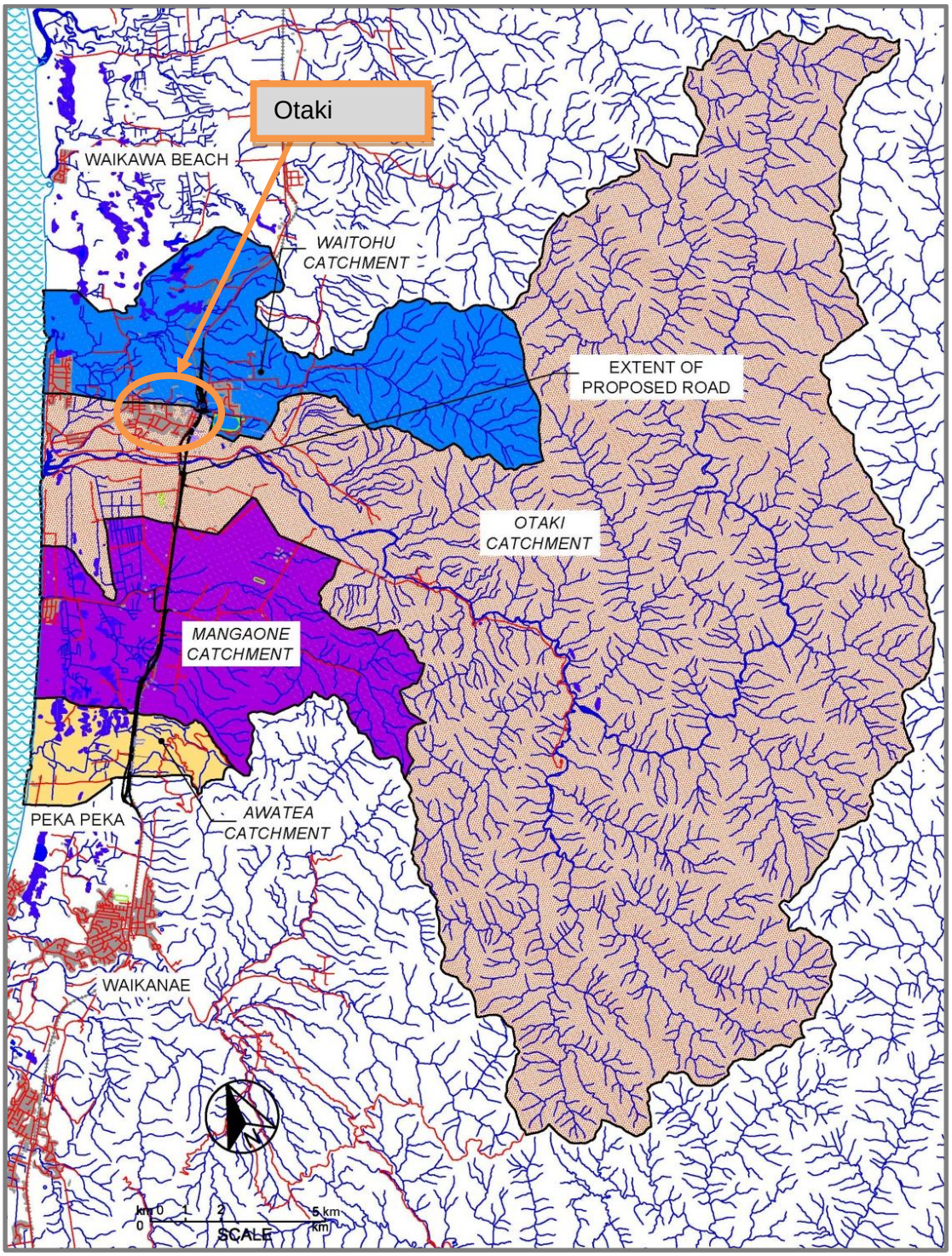

Figure 2 - The four major catchments that the project lies within

There are a further eight catchments in the range 100ha to 500ha, and over 10 catchments smaller than 100ha. There will be waterways (and waterway crossings and potential discharge points) associated with each of these catchments. See Figure 3.

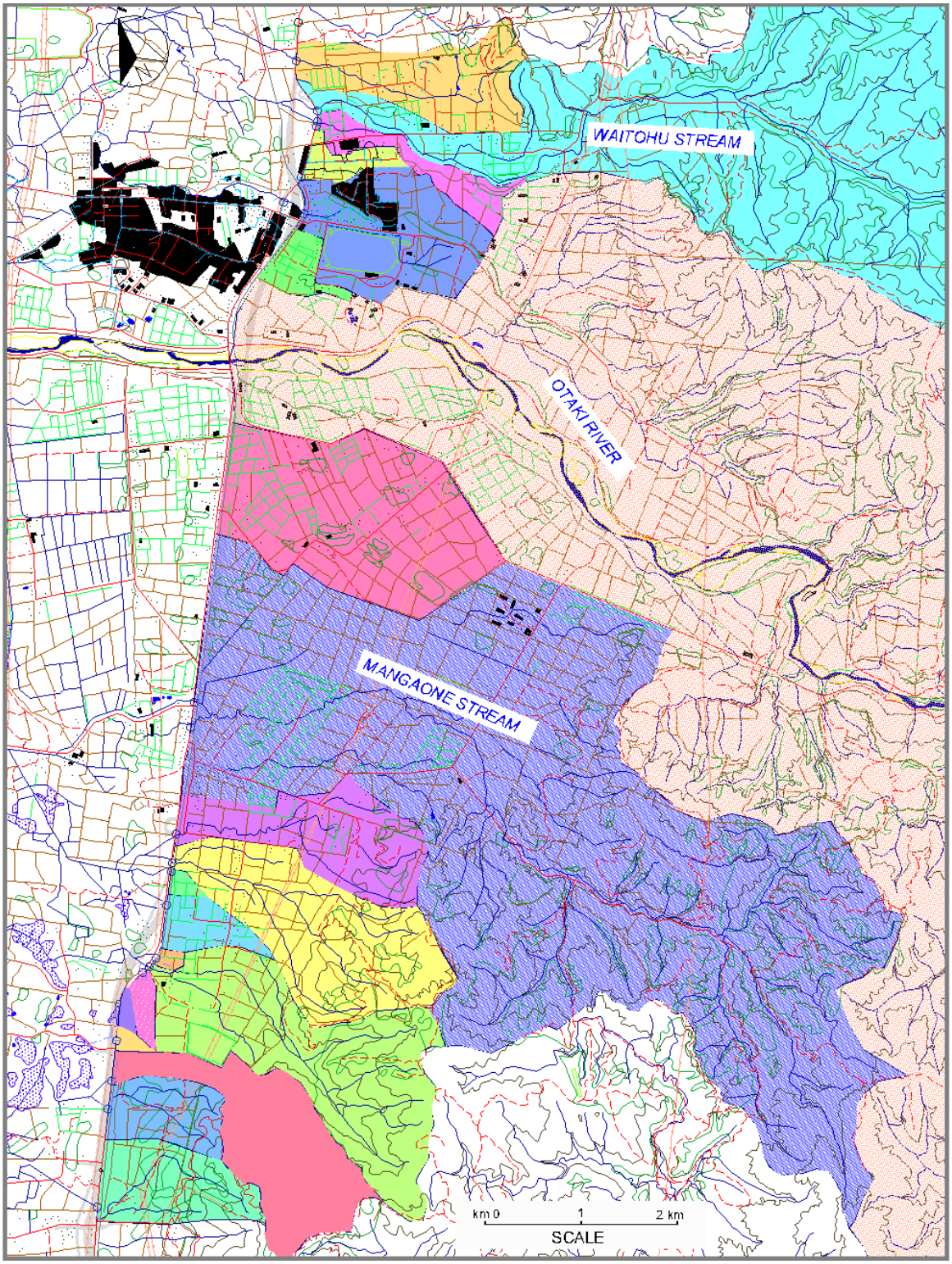

Figure 3 - Catchments associated with existing SH1 culverts

5 Effects

For the purposes of this effects-assessment, we have assumed that future traffic volumes will be the same with or without the project. Some of the effects descried (e.g. contaminations) will be worsened by additional traffic; however most will be the same.

5.1 Potential Social Effects

From a stormwater perspective, the direct potential effects on people is the increased level of service of the expressway (decrease in the frequency of road flooding) and changes to the flooding risk to their property. There are also indirect potential effects on people due to changes to the environment; however these are covered in Section 5.2.

5.1.1 Flooding of Local Road Underpasses

There is potential for any local road underpasses to be flooded in storm events. This was the main stormwater risk identified when considering options for junction configurations. It should be noted that the preferred option being assessed has removed this effect by eliminating underpasses from the design.

5.1.2 Increase in Passability (level of service) during Major Storm Events

The current SH1 is subject to overland flow (flooding) in less than a 1% AEP storm event at various locations along the project route, which would render the current road impassable. The locations currently at risk from flooding include sections of road through Otaki including at the Waitohu Stream and just south of the Te Manuao road junction.

The potential effects of the scheme would mean that the new state highway would normally remain open in a 1% AEP storm event.

5.1.3 Increased Rainwater Runoff – Flood Levels

The increase in impermeable pavement area (of the expressway) will create an increase in stormwater runoff. This is because the paved surface does not allow any infiltration and the removal of vegetation precludes water loss by evapotranspiration.

The potential effect of this is an increase in flow downstream of the expressway. However as the expressway covers a very small proportion of the catchments, the increase in flood levels will be small, and only become significant when combined with the cumulative effects of development.

5.1.4 Local Water Level Upstream of Culverts

The water level just upstream of the Project culverts may be greater than compared to not having the culvert (and expressway) there. The design will aim to minimise this effect and keep it within the designation where possible.

5.2 Potential Environmental Effects

From a stormwater perspective, the direct potential effects on the environment includes short term increase in suspended solids discharged to the receiving environment, increases in the volume of stormwater runoff and changes in the pollutant load discharged to the environment.

5.2.1 Changes to Pollutant Load

Road pollutants (such as zinc, copper, litter, cigarette butts, rubber, oil, grease) are not generated by the road itself but by the cars and people that use the road. Pollution hot spots are generated at sharp bends/intersections/congestion points (where motorists brake heavily).

In general, as the road users switch from the existing SH1 road to the expressway the overall level of contaminants generated will remain the same. The contaminants that are generated by the users of the expressway will be offset by the decrease of contaminants generated on the existing SH1.

Considering contaminant hot spots: the potential effect of the Project is to reduce the contaminant load at existing hot spots (by diverting traffic away onto the expressway); at the same time no new hot spots are being created on the expressway (as it has no traffic lights, roundabouts or sharp bends).

5.2.2 Short-term Increase in Sediment Laden Discharges

During construction there is the potential for exposed soil to be eroded during rainstorms. An exposed earthworks site has the potential to discharge 2000 times the sediment compared to an undisturbed site (this is applicable to all earthworks sites). Fortunately this effect is limited to the time that the soil is exposed, and can be largely mitigated by good site management.

5.2.3 Increased Rainwater Runoff – Stream Erosion

The increase in impermeable pavement area (of the expressway) will create an increase in stormwater runoff. This is because the paved surface does not allow any infiltration and the removal of vegetation precludes water loss by evapotranspiration.

The potential effect of this is an increase in erosion in the streams that the expressway discharges to.

5.2.4 Changes to Water Flow Patterns

The Project has the potential to affect the water flow patterns, however the expressway is adjacent to the existing SH1 and the NIMT, and so natural flow patterns have already been altered. Further minor alteration to flow patterns due to the expressway can be expected.

5.2.5 Fish Passage

The Project has the potential to block fish migration patterns at all the streams that it crosses. Culverts designed with only minimum hydraulic consideration in mind, by default, tend to have features that prevent fish from migrating. These features include: perched culvert entrances, wide shallow flow on aprons or box culvert floors, and high velocities.

Fish that will be affected are known as obligatory migrators and can be classified as follows (McKeown 1984):

- Diadromous fish migrate between salt and fresh water (e.g. Eel[1] (see Figure 4), Inanga, Koaro, Banded Kōkopu, Giant Kōkopu, and Shortjaw Kōkopu):
- Potamodromous fish only move within freshwater systems

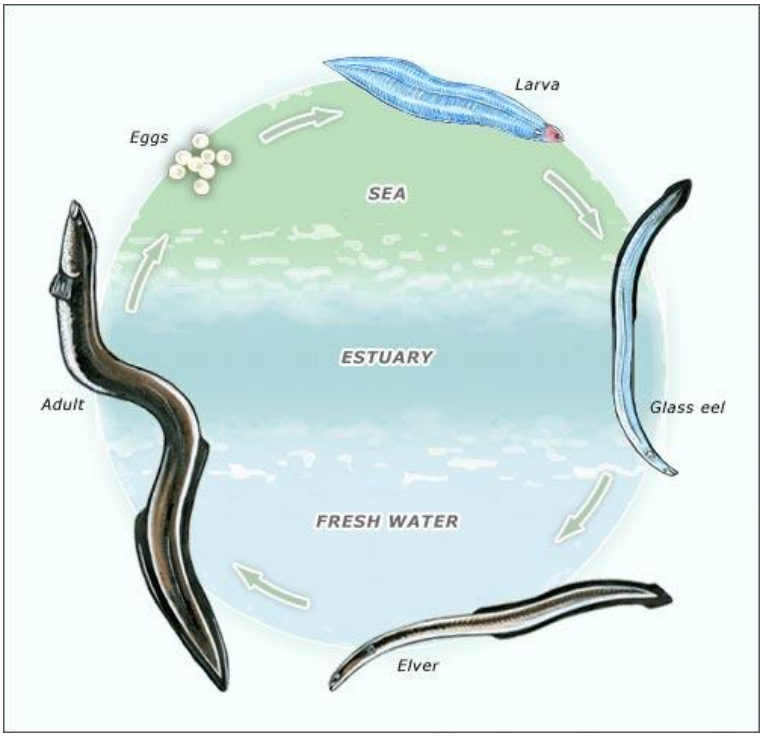

Figure 4 - Eel life cycle (http://www.teara.govt.nz/en/eels/3/1)

However the Project cannot be viewed in isolation. On a given stream, culverts and other structures (flood gates, weirs, and fords) need to be negotiable by the target fish species to migrate from their normal habitat to the sea and back. It is possible (even likely) that there are man-made barriers to fish passage (for some, if not all

[1] Life cycle of New Zealand eels: As NZ eels have never been seen spawning, their lifecycle is based on what scientists think happens. In autumn, adult eels leave fresh water and enter tropical seas somewhere in the South Pacific, where in deep water females release eggs. Males fertilise them. Adults die after spawning. Eggs hatch into larvae that float to the surface and drift back towards New Zealand. They may take about 17 months to arrive. They then change into glass eels – transparent baby eels. These enter estuaries and turn darker – from which point they are known as elvers. Elvers move upstream and find a suitable place to live, where they grow into adults. Over a decade (or more) later, adult eels head out to sea to spawn and the cycle continues. (Te Ara - The Encyclopedia of New Zealand).

species) downstream of the proposed expressway. If this is the case then a new barrier would have no further effect.

Once all the downstream barriers have been removed (through the ongoing process of culvert replacements that include fish passage) the culverts under the proposed expressway will then determine whether there is connectivity within a given stream.

6 Degree of Effect

The degree of potential effect has been rated using guidance contained in NZTA PSF/13. The individual effects have been rated in the table below and an overall rating given. The ratings are given firstly without any stormwater treatment or attenuation and then with stormwater treatment and attenuation (which has now been included in the scheme design).

Table 1 – Effects ratings table

Effect	Potential Rating (no mitigation)	Comments	Rating (with mitigation)
Flooding of local road underpasses	Low (negative)	Major but short term negative effect that is difficult to avoid, reduce or mitigate if underpasses are used. However local road underpasses have been removed from the Project so this effect has been avoided.	N/A
Increase in passability (level of service) during major storm events	Medium (positive)	Major but short term positive effect that has the potential to save lives by maintaining connectivity for emergency vehicles in a major flooding event.	Medium (positive effect, therefore no mitigation necessary)
Increase rainwater runoff – flood levels	Low (negative)	Limited and short-term negative effect. Small increase in flood levels expected due to small areas of road compared to total contributing catchments. Effects significant on a cumulative basis only when effects from other multiple or significant developments are added together. By incorporating peak flow attenuation this effect can be avoided up to the 1% AEP storm event.	Neutral
Local water level upstream of culverts	Low (negative)	Negligible and short-term negative effect. Effect expected to be limited to small areas of rural land. Effect can be reduced to within the designation by increasing the size of culverts.	Neutral
Changes to pollutant load	Low (positive)	Limited and medium-term positive effect. Even with no road runoff treatment on the expressway, there will be less pollutants generated by the same traffic. This is because traffic on the expressway (as compared to the existing SH1) will have less reason to brake hard and turn sharply. The expressway is also considered a safer road so there is expected to be less accidental spills.	Medium (positive)
Short term increase in sediment laden discharges	Medium (negative)	With no sediment and erosion control the effects of sediment loss from the land to aquatic environments can be significantly detrimental, particularly when cumulative effects from other developments are considered. By good site practices these effects can be reduced.	Low (negative)

Effect	Potential Rating (no mitigation)	Comments	Rating (with mitigation)
Increased rainwater runoff – stream erosion	Low (negative)	As a percentage of total flow, the increase is small. Even considering the cumulative effects of the maximum development allowed under the District Plan zoning, the effects are only deemed significant for certain sections of the expressway. With inclusion of extended detention in certain places the stream erosion effects can be avoided.	Neutral
Changes to water flow patterns	N/A	As the flow patterns has already been changed significantly by the existing SH1 and the NIMT, any further minor alterations are expected to have a negligible effect.	N/A
Fish passage	Medium (negative)	Far reaching long team effect although limited to fish populations. All downstream fish barriers need to be removed for this benefit to be realised. Over time we assume that existing barriers will be removed. As such all new culverts are to be installed with provision for expected fish species.	Neutral
Overall rating	Low (negative)		Low (positive)

During construction there will be an overall negative stormwater effect, but in the long-term the overall stormwater effect will be positive.

7 Requirements

The requirements that this Project is subject to, are set out at a National, Regional and Territorial level. NZTA also have their own requirements.

7.1 National Requirements

The Freshwater Fisheries Regulations (1983) establishes the requirements for the protection of freshwater fish habitats and provision of fish passage (part 6).

The Resource Management Act promotes the sustainable management of natural and physical resources. This allows the development of natural resources whilst:

- RMA seciton5.2.b; ‘safeguarding the life-supporting capacity of air, water, soil and ecosystem;
- RMA seciton5.2.c; ‘avoiding, remedying, or mitigating any adverse effects of activities on the environment’.

Section 17 of the RMA also details the duty to ‘avoid, remedy, or mitigate adverse effects’. The power to enforce this duty is passed to the consenting authority. A best practicable option approach can be used at the discretion of the consenting authority and is currently considered best practice stormwater management approach by the industry. In determining the best practicable option, regard must be given to:

- The nature of the discharge and sensitivity of the receiving waterway.
- The financial implications (including maintenance) and effects on the environment when compared to other options.
- The current state of technical knowledge and the likelihood that the option can be successfully applied.

At a National level, the government has published Nation Policy Statement (NPS): Freshwater Management 2011. This NPS is a 'first step to improve freshwater management at a national level'; it identifies the values of freshwater and sets objectives and policy for both quality and quantity of water, integrated management and Tangata Whenua roles and interests.

To put this into practice: there are the NZTA stormwater standards[2&3] intended to be applied as minimum standards nationally (that address both quantity and quality effects) and local council guidelines that address stormwater quantity effects.

7.2 Regional Requirements

GWRC requirements at this time are focused on control and reduction of sediment laden discharges during construction and provision of ecological (fish) passage in waterways. To this effect GWRC guidance documents include:

- Erosion and Sediment Control Guidelines for the Wellington Region, GWRC, September 2002 (update pending).
- Fish-friendly culverts and rock ramps in small streams, GWRC, 2003.

At the moment long-term stormwater discharges are a permitted activity however GWRC is currently reviewing this rule.

7.3 District Requirements

Kapiti Coast District Council (KCDC) requirements focus on both the quantity and quality of long-term stormwater discharges. KCDC guidance documents include:

- Subdivision and Development Principles and Requirements, KCDC, 2005.
- Isohyet Based Calculation of Design Peak Flow – Isohyet guidelines and charts, SKM (produced on behalf of KCDC), 2005.
- Update of Kapiti Coast Hydrometric Analyses – updated rainfall analysis, SKM, August 2008.
- Stormwater Management Strategy, KCDC, 2009.

[2] Stormwater Treatment Standard for State Highway Infrastructure, NZTA, May 2010

[3] **Draft Erosion and Sediment Control Standard for State Highway Infrastructure, NZTA August 2010**

7.4 Client Requirements

NZTA's requirements vary and include both the quantity and quality of long-term stormwater discharges, erosion and sediment controls and the hydraulic performance of stormwater assets. NZTA document include:

- Highway Surface Drainage, NZTA, 1977.
- Bridge Manual Second Edition, NZTA, 2003 (and amendments 2004, 2005).
- Climate Change Position Statement, NZTA, 2004.
- Stormwater Treatment Standard for State Highway Infrastructure, NZTA, May 2010.
- NZTA Environmental Policy Manual September 2010.
- Draft Erosion and Sediment Control Standards for State Highway Infrastructure, NZTA August 2010.

7.5 Other Documents

Other guidance documents that may be pertinent to providing best practice solutions include:

- TP131 Fish Passage Guidelines for the Auckland Region, ARC, 2000.
- TP10, Stormwater Management Devices: Design Guidelines, ARC, 2003.
- Specification for the installation of pipelines on railway land, Ontrack, 2007.
- Draft Drainage Design Guidelines, Ontrack, January 2008.
- Track and civil design parameters summary, Opus/Ontrack, 2008.
- TP366 Culvert Barrel Design to Facilitate the Upstream Passage of Small Fish ARC, 2008.
- TR2009084 Fish Passage in the Auckland Region ARC, 2009.
- NZS4404:2010 Land Development and Subdivision Engineering, 2010.

8 Addressing Effects and Meeting Requirements

As part of the design process, the effects identified in Section 5 and requirements identified in Section 7 have been considered. The effects have been avoided and reduced as much as practicable within the design. Avoidance and reduction of individual effects are detailed below.

8.1 Addressing Social Effects

8.1.1 Flooding of Local Road Underpasses

The stormwater effect of most concern earlier in the Project evolution, was the inundation of local road underpasses in storm events. This effect has been completely avoided by replacing the underpasses with bridges in the design.

8.1.2 Increase in Passability (level of service) during Major Storm Events

The design of the expressway (including the waterway crossings) means that in storm events up to and including the 1% AEP event, the expressway will be passable. In comparison, the existing SH1 would not be passable in a 1% AEP event. As this is a positive effect no mitigation is required.

8.1.3 Increase Rainwater Runoff – Flood Levels

Whilst there will still be an increase in rainwater runoff from the expressway surface, the adverse effect of increased downstream flood levels has been avoided for events up to the 1% AEP storm event.

The effect has been avoided by the introduction of peak flow attenuation into the design for all parts of the road (except those that discharge into the Otaki River as the effect here is considered negligible). The peak flow attenuation takes the form of attenuation swales and stormwater attenuation ponds.

8.1.4 Local Water Level Upstream of Culverts

The potential increased water levels, just upstream of culverts have yet to be assessed. This is because it will depend on the detailed design of the culverts which has not happened yet. As such the extent of this effect can be reduced (and ideally kept within the designation) during detail design. Also the designation has not been set and could be extended to include the extent of this effect.

Typically the impact of a locally increased water level is very low as only a small amount of rural land is affected.

8.2 Addressing Environmental Effects

8.2.1 Changes to Pollutant Load

As described in Section 5.2.1, this could be considered a slightly positive change if the expressway was built with no road runoff treatment. As the expressway is being built with the best practicable road runoff treatment, overall pollutant load entering the waterways, from the road users will considerably decrease.

The existing SH1 does not have any road runoff treatment. Once the road users switch to the new expressway (which will have road runoff treatment) the majority of pollutants the road users generate will be captured and prevented from entering the receiving waterways.

8.2.2 Short-term Increase in Sediment Laden Discharges

The effects of increases in sediment laden discharges during the construction period will be reduced as far as practicable, by compliance with both GWRC's guidelines and NZTA's Erosion and Sediment Control draft standards.

Erosion and sediment control measures will be installed, monitored and maintained throughout the works to control and mitigate the effects of sediment runoff until the site is stabilised, all to the satisfaction of the relevant consenting authorities. Key principles of sediment control include:

- Keeping disturbed areas as small as possible and time of exposure as short as possible by staging construction.
- Protecting disturbed areas against runoff from undisturbed areas upslope of the site by installing perimeter controls such as clean water diversion drains.
- Keeping on-site runoff velocities as low as possible.
- Retaining sediment on site.
- Progressively stabilizing disturbed areas.
- Controlling erosion at source.
- Retaining existing vegetation as far as possible.
- Inspecting and maintaining sediment control devices regularly.

Typical construction sites have a range of sediment control measures with devices chosen to meet the site constraints. A well-managed site would be expected to have a sediment loss reduction of 60 to 90%.

8.2.3 Increase Rainwater Runoff – Stream Erosion

Whilst there will still be an increase in rainwater runoff from the expressway surface, the adverse effect of increased downstream stream erosion has been avoided.

The effect has been avoided by the introduction of extended detention for parts of the road where the maximum potential imperviousness is greater than 3% (an increase of 3% imperviousness, due to urbanisation, is when streams start to experience increased erosion and degradation).

Extended detention effectively captures the water quality volume (defined as the 90th percentile 24 hour rainfall depth) and releases it over 24 hours (1.2 times the water quality volume for unstable streams).

8.2.4 Changes to Water Flow Patterns

The extent of the changes to the water flow patterns are not yet fixed as this will depend on the detail design. At this stage the changes to the flow patterns have

been reduced as far as is practicable by including culverts at each waterway location.

8.2.5 Fish Passage

All waterway crossings need to have fish passage considered. There will be some culverts where the waterways are intermittently flowing; these are unlikely to require fish passage. However most culverts under the proposed expressway will be on permanently flowing streams and therefore will be required to be designed and constructed with fish passage in mind.

For significant culverts, consideration needs to be given to providing a natural substrate within the culvert. Possibilities include partly buried culverts and culverts with no bases. Figure 5 is an image from TR2009084 which shows a good example of fish passage through a culvert. The design incorporates 'natural' banks within the culvert providing some cover from predators and gives variation to the flow depth. Although this length of stream has been culverted, the lost habitat has been partly recreated.

Figure 5 - Example of good fish passage (in a bottomless culvert)

9 Mitigation Proposals

The majority of mitigation costs (associated with swales and ponds) have already been identified and captured in the project cost estimate. The only additional mitigation measures (and associated costs) that have not already been included in the Project cost estimate are those associated with fish passage.

Larger culvert sizes have been allowed for but the additional internal components (e.g. baffles, blocks, and substrate) and the associated labour cost to install these features has not been included. The cost of including fish passage in culverts will range depending on culvert size and the grade it is installed at. Generally the internal components will be of nominal cost with the labour

cost to install them being the major component. At this stage, an allowance of two man hours per culvert meter should be made for installing some type of baffle solution.

A better ecological solution would be a bottomless culvert. This would consist of a strip or piled foundation, with an arch or square culvert spanning the foundations. The advantage of this, is that there is very little disturbance to the existing stream bed. This type of solution will cost more than a typical culvert however potential offset mitigation costs (of disturbing stream beds) could be avoided.


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